Two-stage treatment of flexor tendon ruptures

Silicon rod complications analyzed in 109 digits

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Complications during two-stage flexor tendon reconstruction may jeopardize the function of the repaired tendons. We reviewed complications encountered in 89 patients (109 digits) treated with a two-stage flexor tendon reconstruction using either silicone or Hunter rods. The complications could be distinguished according to the stage of reconstruction in which they occurred. Complications during stage I included rod buckling, rupture of the distal end of the rod, rod migration, synovitis and infection, and during stage II included distal rupture of the graft juncture, loose graft, tight graft, bowstringing, and flexion deformity of the PIP and DIP joints. The commonest complication was a flexion deformity of the PIP and/or DIP joint which was related to the surgical procedure. These deformities could easily be corrected in all cases with night splints.

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Extensive damage to the flexor tendon sheath results in adhesion formation. This is one of the main causes which prevents active finger flexion; the adhesions obliterate the free gliding mechanism of the tendons within the tendon sheath. This remained a serious problem in the repair of flexor tendons in zone II up until 1965 when James Hunter with his pioneering first demonstrated that implantation of a silicone-dacron tendon prosthesis led to the formation of a pseudo-tendon sheath. This new sheath had a smooth and gliding surface which enabled the insertion of a secondary tendon graft, thus restoring active finger flexion (Hunter 1984, Schneider 1985a and 1985b, Culp 1993, Soucacos 1995).

While primary or delayed primary tendon repair can be accomplished with excellent results in sharp injuries in zone II, primary tendon repair is contraindicated in severely crushed fingers with flexor tendon rupture in zone II. The only solution in these cases is either to use a tendon graft or a two-stage tendon reconstruction using either silicone rods or Hunter tendon implants (Pulvertaft 1956, Hunter 1984, Wilson 1985, Soucacos 1995, 1995). Flexor tendon grafting, even though well-documented, is not free from complications. Among these is mainly the formation of adhesions which can lead to impairment of the gliding mechanism with potential failure. Total failure occurs, if tenolysis can not solve the problem (Pulvertaft 1956, Wilson 1985, Strickland 1985a and 1985b). In these cases it becomes evident how important two-stage reconstruction of the flexor tendons using silicone rods and Hunter implants is in terms of salvaging the function of finger flexion.

Complications during two-stage flexor tendon reconstruction using an implant can be separated in those occuring in stage I and those occuring in stage II. Complications which have been reported to occur in stage I include skin necrosis, rod buckling, rupture of the distal end of the silicone rod or Hunter implant, rod migration, synovitis and infection. Complications which have been reported in stage II include distal or proximal rupture of the graft juncture, grafts which are too loose or too tight, bowstringing, impingement of the proximal suture in the sheath at the level of the wrist, flexion deformities of the PIP and/or DIP joints and infection (Weinstein et al. 1976, Hunter 1984, Schneider 1985a and 1986, Soucacos 1995).

We reviewed complications encountered in 89 patients (109 digits) treated with two-stage flexor tendon reconstruction.

Patients and methods

A total of 89 patients with flexor tendon injuries in zone II in 109 digits were reviewed at the Department of Orthopaedic Surgery, University of Ioannina. 11 patients who had multiple digit amputations under-

went replantation procedures. The indications for a two-stage flexor tendon reconstruction using silicone rods or Hunter implants were as follows: 1) patients with severe scaring of the tendon bed (type II-V, according to Boye), where primary suture or tendon grafting were contraindicated; 2) multiple digital amputations with extensive damage of the fibro-osseous canal in those cases in which replantation was possible; and 3) cases in which primary suture and grafting techniques had failed. In all cases, the digits were required to have a total passive motion of no less than 220° and it needed to be possible to passively bend the tip of the finger to at least 2 cm from the distal palmar crease.

Results

Complications in stage I

Of the various complications which are known to occur in stage I, the following were observed in the present series (Table 1):

Skin necrosis: Even though it is considered as a potential complication, no skin necrosis was observed in the present series. This was achieved by careful planning of the Brunner incision (Brunner 1967). In particular, care was taken to always have zigzag angles of more than 45°.

Rod buckling: Only two patients with a ruptured flexor tendon in the middle finger and index finger, respectively, demonstrated buckling of the rod. This was related to excessive tightness and obstruction at the level of the A2 pulley.

Rupture of the distal end of the silicone rod or Hunter tendon implant: This was observed in 6 cases; one in one patient who had 2 fingers reconstructed, while the remaining occurred in 5 patients in whom only 1 reconstruction was performed. Rupture of the distal end was related to a fixation which was not secured at the distal end of the implant. The problem was solved by opening the volar aspect of the distal phalanx and carefully fishing out the implant with aid of a tendon retriever. The patients were left for an additional month before proceeding to the second stage of the procedure.

Rod migration: Rod migration was related to the rupture of the distal end of the implant, where as a result of finger motion, the implant migrated proximally. This is a very serious complication, because if the rod migrates to far proximally, it is difficult to fish it out. Moreover, it also prevents the formation of the silicone sheath which is to receive the tendon graft in the second stage of the procedure. To prevent this complication the patient is advised to have a xerogram prior to stage II, so as to be able to spot whether the distal end of the implant has remained in place or has migrated proximally. Rod migration was observed in the 6 patients with rupture of the distal end of the implant. In 4 patients the rod had migrated slightly proximal to the DIP joint, thus it was relatively easy to fish the rods out and to re-secure them. In these cases, surgery proceeded uneventfully to stage II. In the remaining 2 patients, the rod had migrated into the palm . As a result the palm had to be opened in order to find the rod for its reinsertion into the sheath.

Table 1. Complications in 89 patients (109 digits) during two-stage flexor tendon reconstruction.

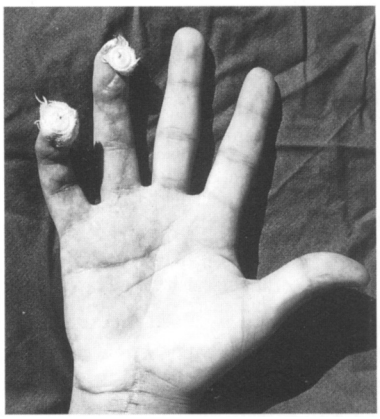
Stage I Complication	n	Stage II Complication	n
Skin necrosis	0	Distal disruption	2
Rod buckling	2	Proximal disruption	0
Distal end rupture	6	Loose graft	6
Rod migration	6	Tight graft	2
Synovitis	1	Bowstringing	1
Infection	3	Impingement flex. deform.	0
		Infection	0

Synovitis: There was only 1 complication of synovitis which was observed in a silicon rod and not in a Hunter tendon implant. The synovitis was diagnosed by swelling of the finger, loss of passive motion and relative pain. It was not clear whether the synovitis was attributable to the implant per se or to foreign materials, such as operating room dust or other particles which may lead to this complication. The one case of synovitis was treated with the administration of antibiotics, splintage of the digit in the resting position and the avoidance of any passive motion.

Infection: Three patients demonstrated infection after the stage I procedure. All were treated with systemic antibiotics, irrigation of the sheath with antibiotics and splinting. Two patients recovered and proceeded uneventfully to stage II, while in the third patient, the rod had to be removed with the patient remaining under antibiotic treatment for 3 months. 6 months later, the rod was reinserted in a second stage I procedure, with a satisfactory outcome.

Complications in stage II

Distal disruption of graft juncture: Distal disruption of the graft juncture can occur if uncontrolled active motion of the digits is undertaken immediately after surgery and the hand remains unprotected by a dorsal splint. 2 patients with disruption of the distal juncture were encountered. They were both successfully treated with reattachment of the graft (Figure 1).



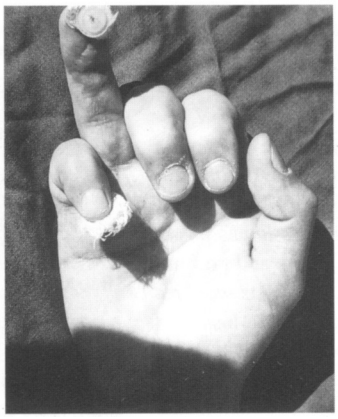


Figure 1. A 24-year-old man with rupture of the flexor tendons in zone II of both the ring and little fingers treated with 2-stage flexor tendon reconstruction. Postoperative view at 4 weeks showing (left) both fingers in extension with the pull out sutures still in place, and (right) the fingers in flexion. Note that while the little finger has assumed satifactory active flexion, the ring finger fails to show flexion due to a distal disruption of the graft juncture.

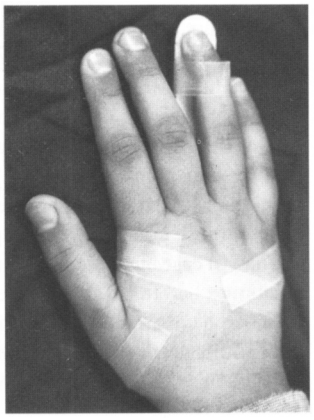


Figure2. Flexion contracture of both the PIP and DIP joint treated with a night splint.

Proximal disruption of graft juncture: No graft disruption at the proximal juncture was noted in this series. This was probably due to the stable fixation of the proximal end of the tendon graft to the distal end of motor tendon using the fish-mouth technique (Pulvertaft 1956).

Loose graft: In 6 patients the graft was found to be loose to the point that the tip of the finger remained 2–4 cm away from the distal palmar crease. These were all treated by plication of the tendon at the level of the wrist. The amount of graft tension is very important and is adjusted in manner so when with the wrist in neutral position, the finger rests in slightly more flexion than the adjacent finger. On the other hand, when the wrist is in flexion, the finger should extend almost completely. As a rule of thumb, tightness is preferred to looseness, as tightness will tend to gradually loosen with time.

Tight graft: 2 grafts were found to be too tight, and both led to an excessive flexion contraction at the PIP and DIP joints. The one case was attributed to a graft which was too short, while the other to a thick graft. In the later case, the superficialis tendon had been used as the tendon graft in a tendon sheath which had been created with a 3mm silicone rod.

Bowstringing: The complication of bowstringing was observed in only one patient. This was related to an inadequate fixation in terms of both number and security of the pulley system reconstruction.

Proximal suture impingement in the sheath: This complication was not observed in any of the patients in the present series. None-the-less, it known to happen frequently, especially if careful care of the patient is not undertaken, particularly in regards to opening the newly created sheath at the level of the wrist so that the sutured junction of the graft to the distal end of the motor tendon can easily pass through during the flexion-extension motion of the digit.

Flexion deformity of the PIP and/or DIP joints: Flexion contracture of 10° was noted in 45% of the patients. This was successfully treated with night splints in all cases (Figure 2).

Infection: No infections were observed in the patients after the stage II procedure of the flexor tendon reconstruction.

Discussion

Each of the complications which occurred in the present series, were considered serious with the potential of altering the final outcome from the point of elongating the duration of treatment with additional re-operations in both stages up to complete failure (Schneider 1985a and 1986, Soucacos 1995). In the present series we found that skin necrosis in stage I could be easily avoided by careful planning using the Brunner approach where the angles of the zigzag incision were kept wide and no less than 45°. Other studies report a similar observation (Culp 1993). Buckling of the rod was always associated with an excessive tightness of the pulleys, particularly of the 2 most important pulleys, A2 and A4. Buckling when it occurred was found to obstruct and prevent the smooth gliding of the implant within the tendon sheath.

Rod migration, another serious complication, was

always related to rupture of the distal end of the implant, secondary to end which was not properly secured. The destructive results were less serious when the implant could be fished out from within the tendon sheath. On the other hand, it was much more serious when the migration had proceeded even more proximally into the palm. In these cases, it was necessary to repeat the entire stage I. Synovitis whether or not it was related to infection, can also be a serious complication. If it were to remain untreated it could risk the outcome of the stage I reconstruction. Infection can the most serious complication of all for stage I. We have found, however, that it can be successfully managed with intrathecal and systemic antibiotics. In cases were the infection was reported not to have regressed, rod removal was unavoidable and the stage I procedure needed to be repeated (Schneider 1985a and 1986, Soucacos 1995, Weinstein et al. 1976)

Distal disruption of the tendon graft juncture tends to occur more frequently and be more serious compared to proximal disruption of the juncture. This is because in proximal disruption of the graft juncture, both the proximal and distal ends of the graft tend to stay in place. In contrast, when the distal end has been disrupted, the distal end of the graft tends to migrate proximally. The complications of either a loose or tight graft, were found to be avoidable when careful attention was given to the amount of tension that had to be given to the graft. The correct amount of graft tension could be determined by adjusting the graft in such a manner that when the wrist was in a neutral position, the finger rested in slightly more flexion than the adjacent finger, while when the wrist was in flexion, the finger extended almost completely.

Bowstringing of the tendon graft was related to inadequate reconstruction of the pulleys, and especially of the A2 and A4 pulleys. Both the number of pulleys reconstructed, as well as the manner in which they were secured were found to be of paramount importance. Bowstringing was catastrophic complication as the tendon was deprived of its anatomic leverage and surgery has to be done from the beginning for both stages.

Flexion contracture deformity of the PIP and/or DIP joints had the highest prevalence compared to the other complications. Flexion contractures are related to factors which exists before surgery, as well as to other factors which present during the two stages of the procedure. Flexion contracture at these levels which exist before surgery have to be corrected prior to stage I or II, or at least during stage I. If not corrected at stage I, it will remain and alter the total range of motion of the finger. On the other hand, flexion contractures which result from the surgical procedure were found to be easily treatable and could be satisfactorily corrected with night splints.

Infection remains a serious threat both for stage I and II in regards to the final outcome. However, infection is less likely to occur in stage II, as compared to stage I because of the relatively limited exposure which takes place in stage II. Thus, while in stage I, the entire volar aspect of the digit, palm and wrist are exposed, in stage II only a small portion of the volar aspect of the distal phalanx and a small portion of the volar aspect of the wrist are exposed for removal of the silicon rod or Hunter tendon implant and insertion of the tendon graft (Schneider 1985a and 1986, Soucacos 1995, Weinstein et al. 1976).

In conclusion, while the staged flexor tendon reconstruction technique proved to successfully manage flexor tendon injuries in zone II in mangled fingers, it bears a potential number of complications which can occur in both stages of the procedure. None-the-less, meticulous technique and awareness of the various complications, as well as their management can help ensure a successful stage flexor tendon reconstruction.

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